

NEPTUNE ORBITER CONCEPTS

Richard A. Wallace and Robert Gershman
Jet Propulsion Laboratory
Pasadena, CA

Abstract

This paper describes the results of a study to update our concepts for the exploration of Neptune to reflect the latest projections for spacecraft technology developments within the next several years. In cooperation with NASA's Solar System Exploration Subcommittee and its working groups, science and mission objectives were established, various options to meet these objectives were defined and compared, and a baseline concept was established.

The overall science goals of the Neptune Orbiter Mission are to study the rings, ring arcs, and shepherd satellites over at least 2 yr; map Triton's surface features, examine its geologic history, surface composition, and internal structure, and monitor its atmosphere and seasonal cycles; examine the composition, structure and dynamics of Neptune's atmosphere; probe Neptune's magnetosphere with extended temporal and spatial sampling; and image and determine the densities of the satellites Larissa, Proteus and Nereid.

Eight instruments were considered part of the baseline payload: a visible imager, an IR-imaging spectrometer, a UV-imaging spectrometer, a thermal-IR spectrometer, an ion-and-neutral-mass spectrometer, a magnetometer, a charged-particle detector and a plasma-wave spectrometer. A large range of sensitivity is desired for the thermal-IR spectrometer (25 to 100 μm) to try to combine the thermal measurement objectives for both Neptune and Triton. Radio occultation science was also included in the baseline, although its mass margin and technology implications were found to be substantial.

A minimum energy transfer from Earth to Neptune would require more than 30 years, which is too long for a planetary mission. For this study, a ten year transfer time to Neptune was established as a constraint. A number of alternatives to a direct transfer were examined. A Jupiter flyby (JGA) offers the most gain of the impulsive/ballistic trajectory alternatives; such a transfer is available for Earth departures in 2005, 2006, and 2007 and then not again until about 2017. A direct JGA transfer leaving in 2007 was selected for study. Several solar electric propulsion (SEP) options were also considered for launches later than 2007, and the study focused on one using an indirect 10-year transfer to Neptune.

Key features of the spacecraft design include an aerocapture ballute estimated at 18 percent of the entry mass, an advanced radioisotope power source (ARPS) and general use of planned X2000 second or third delivery capabilities. The SEP systems operate at 24KW using Ultraflex arrays. The telecom system uses a 6 m "astromesh" antenna operating at both X and Ka bands to satisfy telemetry and radio science requirements. Adaptive feed and a beacon signal from Earth are used to provide the required precise pointing. The lander requirement is consistent with the capability of launch vehicles in the Delta 4/Atlas 5 class.

Neptune Orbiter is a technology hungry mission. The mass and cost estimates developed for the baseline concept are based on the following developments being successfully completed.

- AEROCAPTURE - using either a ballute (which is assumed in the baseline) or an advanced heat shield.
- NEPTUNE DELIVERY CAPABILITY - improvements in SEP performance coupled with substantial cost reductions. Solar sailing may be an important alternative.
- COMMUNICATIONS - Work is needed on light weight antennas, adaptive feed, and interactions with attitude control to confirm that both telemetry and radio science can be implemented in systems of affordable mass.
- POWER - Continued development of efficient ARPS capability and development of low-cost solar arrays for the SEP system.
- MICRO-SPACECRAFT TECHNOLOGIES - Across-the-board advances are mandatory for a Neptune mission and were assumed in all options.
- DATA QUANTITY REDUCTION - A Neptune mission will utilize a combination of advanced data compression and autonomous selection of data for downlink to optimize science return.

The cost of the baseline SEP concept is marginally consistent with the scope of the Outer Planets program. A ballistic (JGA) version could be less expensive but is not available in 2008-2016.